An exploration of GOA northern and southern rock sole stock assessment models for 2014

Teresa A'mar

Resource Ecology and Fisheries Management Division
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE., Seattle, WA 98115

Introduction

This document represents an effort to respond to comments made the GOA Plan Team and the SSC on the 2013 assessments of the northern and southern rock sole (*Lepidopsetta polyxystra* and *bilineata*) stocks in the Gulf of Alaska (A'mar et al., 2013). In order to allow for exploration of a wide variety of modeling assumptions, this preliminary overview focuses on model development rather than application of the same model(s) to multiple data sets. Specifically, the model configurations presented here are applied to data through 2013.

Comments from the Plan Teams and SSC

Plan Team Comments from the November 2013 Minutes

PT1: "For northern and southern rocksole models, the Team discussed recommendations compiled in September as presented by the author. These include:

- *Work with fishery observer program on U/N/S rock sole catch recalculation*
- *Continue with SS models for U, N, and S*
- *Investigate empirical growth (weight-at-age)*
- *Investigate data weighting*
- *Investigate methods to address (male) M*
- *Investigate methods for calculating ABCs based on U, N, and S model estimates*

The Team notes that estimation of natural mortality is a lower priority than other considerations to be evaluated."

Response:

- The fishery observer species proportion recalculations are in progress.
- The Stock Synthesis models are described below.
- Empirical growth has been investigated by using conditional age-at-length, which uses all of the survey samples with valid ages and lengths. There are few undifferentiated rock sole age samples and no northern or southern rock sole age samples from the fishery observer program, so no fishery age composition data are available. The use of empirical weight-at-age data in Stock Synthesis

This information is distributed solely for the purpose of pre-dissemination peer review under applicable information quality guidelines. It has not been formally disseminated by the National Marine Fisheries Service and should not be construed to represent any agency determination or policy.

usually requires the use of fishery and survey selectivity-at-age curves, which requires fishery and survey age composition data.

- Data weighting was investigated by increasing the emphasis of fitting the model configurations to the survey indices.
- Comparisons were made between model configurations with and without male M estimated, and the model configurations used in this analysis estimate male M.
- The methods to calculate species-specific ABCs are being investigated, as the proportion of rock sole catch that is northern or southern is uncertain.

*PT2: "**The Team recommends that the author provide a suite of models and discussion points for Team review in September and an updated full assessment in November.** Prioritization should be given to evaluation of empirical weights at age followed by species and sex ratio assumptions, in particular as it relates to catch."*

Response: The use of empirical weight-at-age data requires both fishery and survey age composition data, and fishery age composition data are not available. The fishery observer species proportion recalculations are in progress.

*PT3: "**The Team further recommends the author look at the ADF&G survey data as an alternate data source.**"*

Response: The evaluation of the use of the ADF&G survey data is in progress. The utility of these data may be limited as the data are not sex-specific.

*PT4: "**The Team recommends the authors complete the stock structure template for northern and southern rock sole for September**"*

Response: The stock structure template is in progress.

SSC Comments from the December 2013 Minutes

*SSC1: "**The SSC reiterates its support for the further development of the rock sole model based on comments from the September and November 2013 Plan Team minutes and our October 2013 minutes. …We agree with the Plan Team that the stock structure template should be completed for northern and southern rock sole.**"*

Response: The stock structure template is in progress.

Summary of the base model configuration

The software used to run the models presented below was Stock Synthesis v3.24S as compiled with ADMB v.11.1.

Model evaluation

Model configurations for 2014

The data used in the model configurations was the fishery and survey data for 1977 through 2013. The survey biomass estimates, length, age, and mean length-at-age data from 1984-1993 are for undifferentiated

(aggregated) rock sole, and the data from 1996 on are species-specific. The fishery catch data are for undifferentiated rock sole; the fishery observer length data from 1977-1996 are for undifferentiated rock sole, and the data from 1997 on are for undifferentiated, northern, and southern rock sole. The annual catch time series for the species-specific model configurations is 60% of the annual rock sole catch, as there is uncertainty about what fraction of the annual rock sole catch is northern and southern rock sole.

Three independent sets of sex-specific model configurations were developed. One set was an undifferentiated rock sole model configuration which used fishery and survey data for undifferentiated, northern, and southern rock sole; the second set was a model configuration for northern rock sole; and the third set was a model configuration for southern rock sole. All of the model configuration sets are independent of each other.

The undifferentiated (aggregated) data model configurations, designated "Urs", included

- 3 periods of sex-specific double normal fishery selectivity-at-length, 1977-1991, 1992-2001, and 2002-2013, with each period containing at least 10 years of samples;
- 3 periods of sex-specific double normal survey selectivity-at-age, 1977-1995, 1996-2004, and 2005-2013, with each period containing at least 4 survey years;
- 3 periods of sex-specific growth, 1977-1995, 1996-2004, and 2005-2013, which allows for the changing ratio of northern to southern rock sole;
- Conditional age-at-length; and
- The selection of estimating natural mortality for males.

The northern and southern rock sole model configurations, designated "Nrs" and "Srs", respectively, each included

- 1 period of sex-specific double normal fishery selectivity-at-length;
- 1 period of sex-specific double normal survey selectivity-at-age;
- 1 period of sex-specific growth;
- Conditional age-at-length; and
- The selection of estimating natural mortality for males.

Preliminary results

The results for the "Urs" and "Srs" model configurations were consistent and well-behaved; the results for the "Nrs" model configurations were less reasonable.

The estimates of total and spawning biomass for "Urs" and "Srs" have a similar pattern (Fig. 1), which is expected, given that a larger proportion of total rock sole survey biomass since species differentiation is southern rock sole. There is also a similar pattern for age-0 recruits for "Urs" and "Srs" (Fig. 2).

The initial fits to the survey biomass indices for "Urs" were moderately good, the fits for "Srs" were mediocre, and the fits for "Nrs" were poor. The weight on fitting to the survey biomass indices was increased incrementally for all 3 sets of model configurations so that the fits to the survey biomass indices were significantly better, as the survey data are assumed to have more information than the fishery data. The resulting weights were 5, 5, and 2 for "Nrs", "Srs", and "Urs", respectively (Fig. 3).

Spawning biomass estimates for "Nrs" and "Srs" have much larger uncertainty intervals for the first half of the historical period, as the catch data start in 1977 and the age and length composition data start in 1996 (Figs. 4 and 5). The fits to the fishery length composition data for northern rock sole seem slightly better for males than for females (Figs. 6 and 7); the fits for southern rock sole seem reasonable for both males and females (Figs. 8 and 9).

The conditional age-at-length functionality was used in these model configurations as this method makes use of each survey age-length sample (Figs. 10 through 13). From the Stock Synthesis User Manual version 3.24S: "Use of conditional age-at-length...is a superior approach because it: avoids double use of fish for both age and size information because the age information is considered conditional on the length information; and it contains more detailed information about the relationship between size and age so provides stronger ability to estimate growth parameters, especially the variance of size-at-age". This functionality was used in the 2013 GOA flathead sole stock assessment.

Comparisons of model configurations with and without estimation of male M were made, with the result that the negative log likelihood (NLL) was around 15 points lower with an increase of 1 estimated parameter when estimating male M for both "Nrs" and "Srs". The estimates of male natural mortality were consistent across the species-specific model configurations which estimated male M. The estimates of male M for "Nrs" were around 0.21 to 0.23, the estimates of male M for "Srs" ranged from 0.22 to 0.23, and the estimates of male M for "Urs" were around 0.21 to 0.23, which differ from the fixed value of 0.2 for both northern and southern females.

	L at A_{min}	L_∞	k			L at A_{min}	L_∞	k	M
SS3 Nrs females	17.93	43.74	0.303		SS3 Nrs males	19.52	36.51	0.294	0.230
SS3 Srs females	17.13	48.85	0.183		SS3 Srs males	18.51	39.28	0.200	0.234
SS3 Urs females #1	17.42	41.75	0.339		SS3 Urs males #1	18.27	35.29	0.352	0.214
SS3 Urs females #2	19.49	45.11	0.227		SS3 Urs males #2	19.18	39.50	0.214	-
SS3 Urs females #3	18.51	48.22	0.168		SS3 Urs males #3	18.35	41.64	0.176	-

For the undifferentiated rock sole model configurations, the estimates of L_∞ increase over the historical period and the estimates of k decrease, for both males and females, indicating that both growth and the ratio of northern to southern rock sole has changed over time.

Table 1 – Likelihood components for Nrs and Srs model configurations with and without male M estimated

	Nrs			Srs	
	with	without		with	without
Parameters	83	82		83	82
TOTAL	4369.6	4384.43		3875.69	3900.41
Survey	-77.46	-77.60		-74.81	-76.54
Fsh length comp	1113.15	1121.44		1040.10	1050.25
Srv length com	126.25	143.62		40.38	59.76
Age_comp	3220.35	3209.68		2871.59	2869.22
Recruitment	-16.00	-16.14		-5.96	-6.85

Figures

Figure 1 – Estimates of spawning biomass for undifferentiated, northern, and southern rock sole

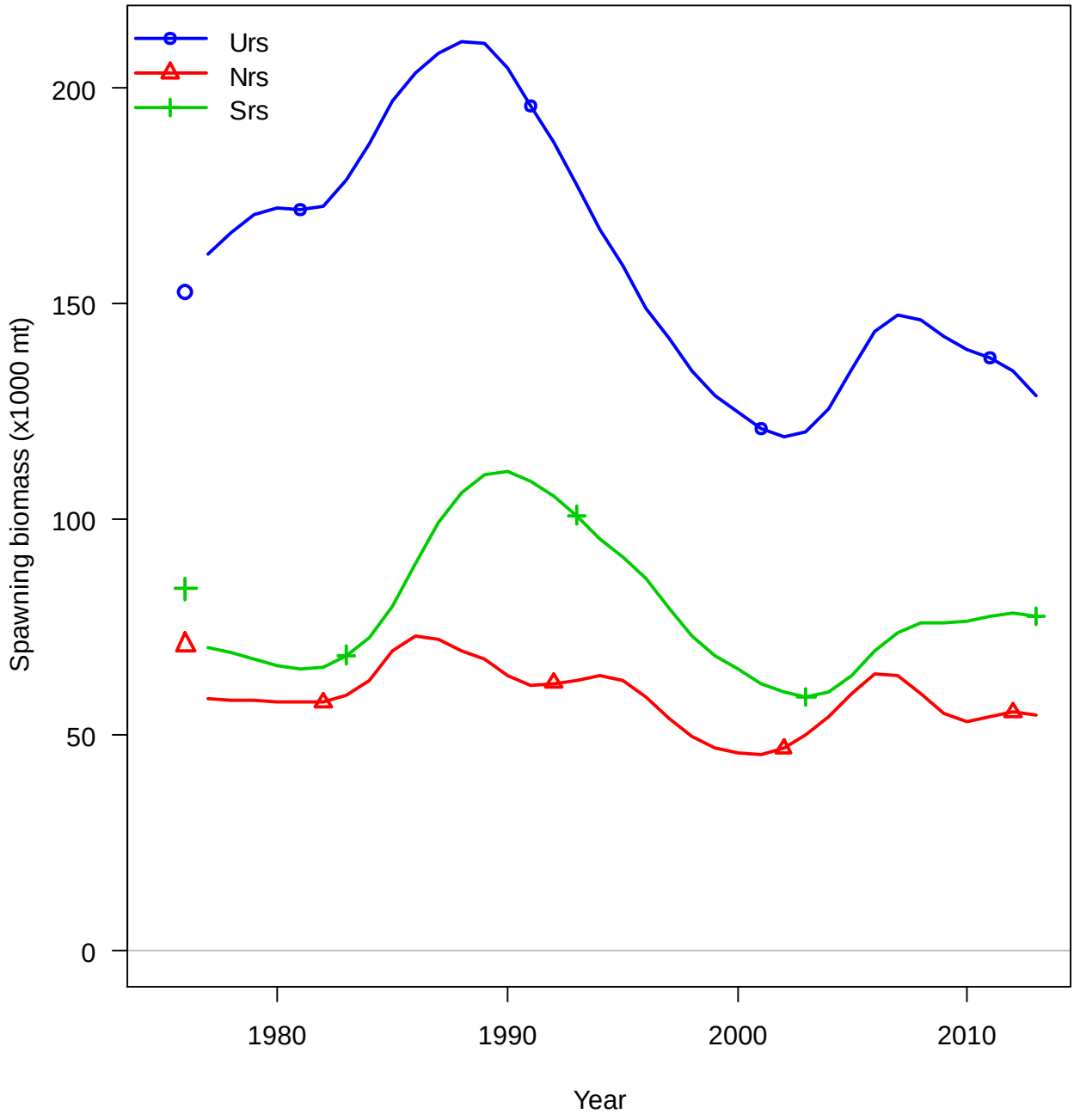


Figure 2 – Estimated of age-0 recruits for undifferentiated, northern, and southern rock sole

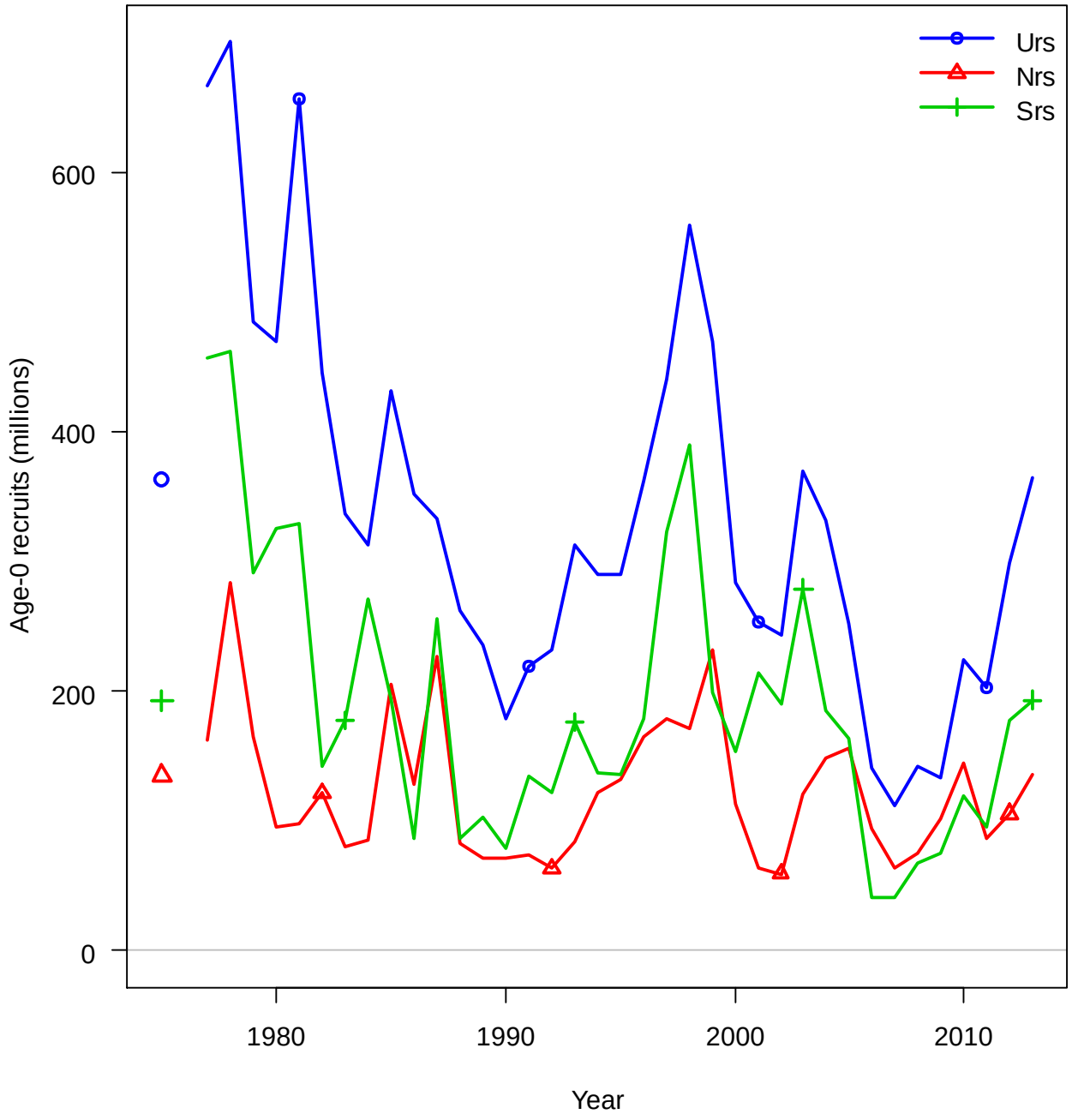
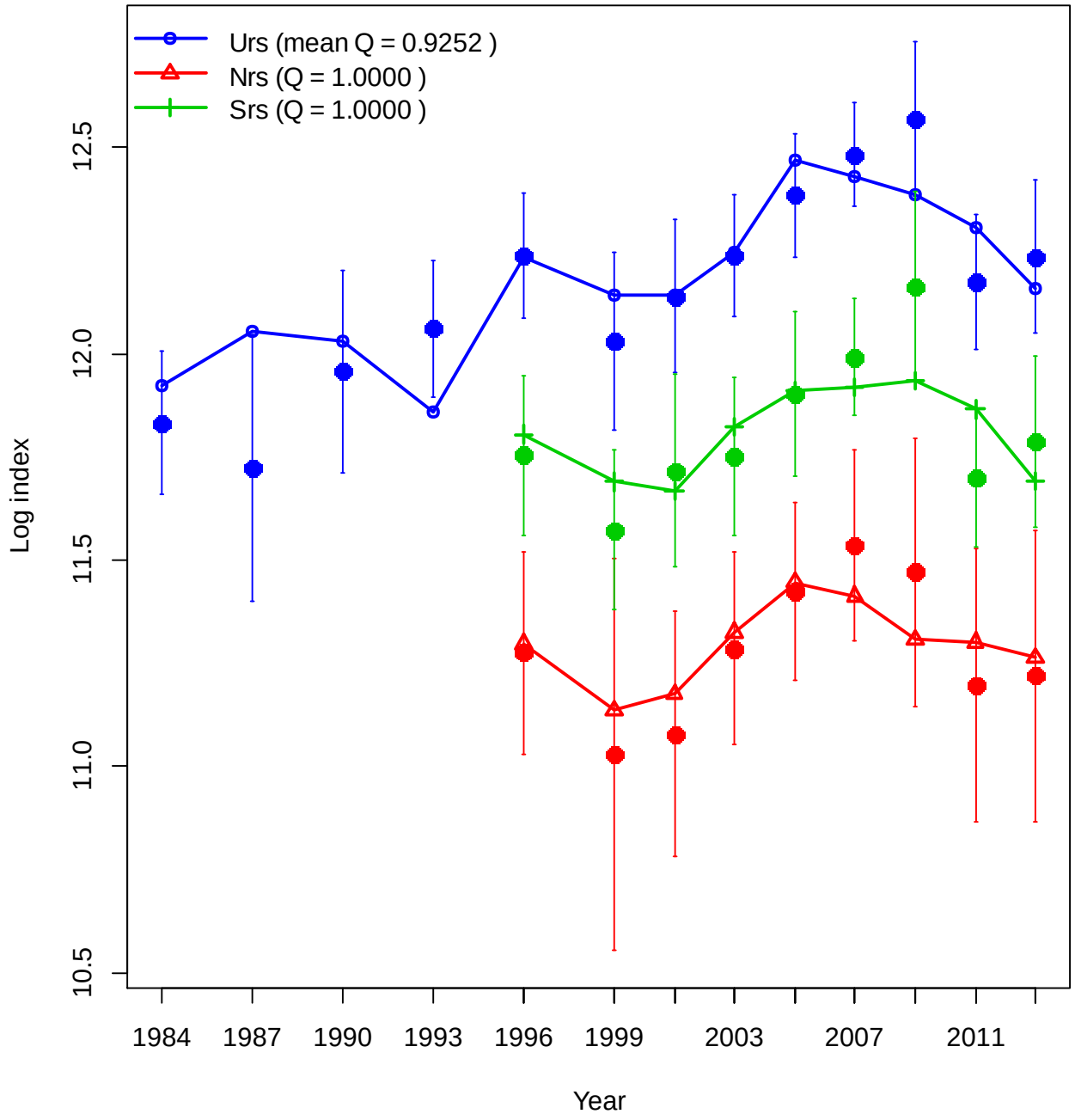


Figure 3 – Estimates of survey biomass for undifferentiated, northern, and southern rock sole



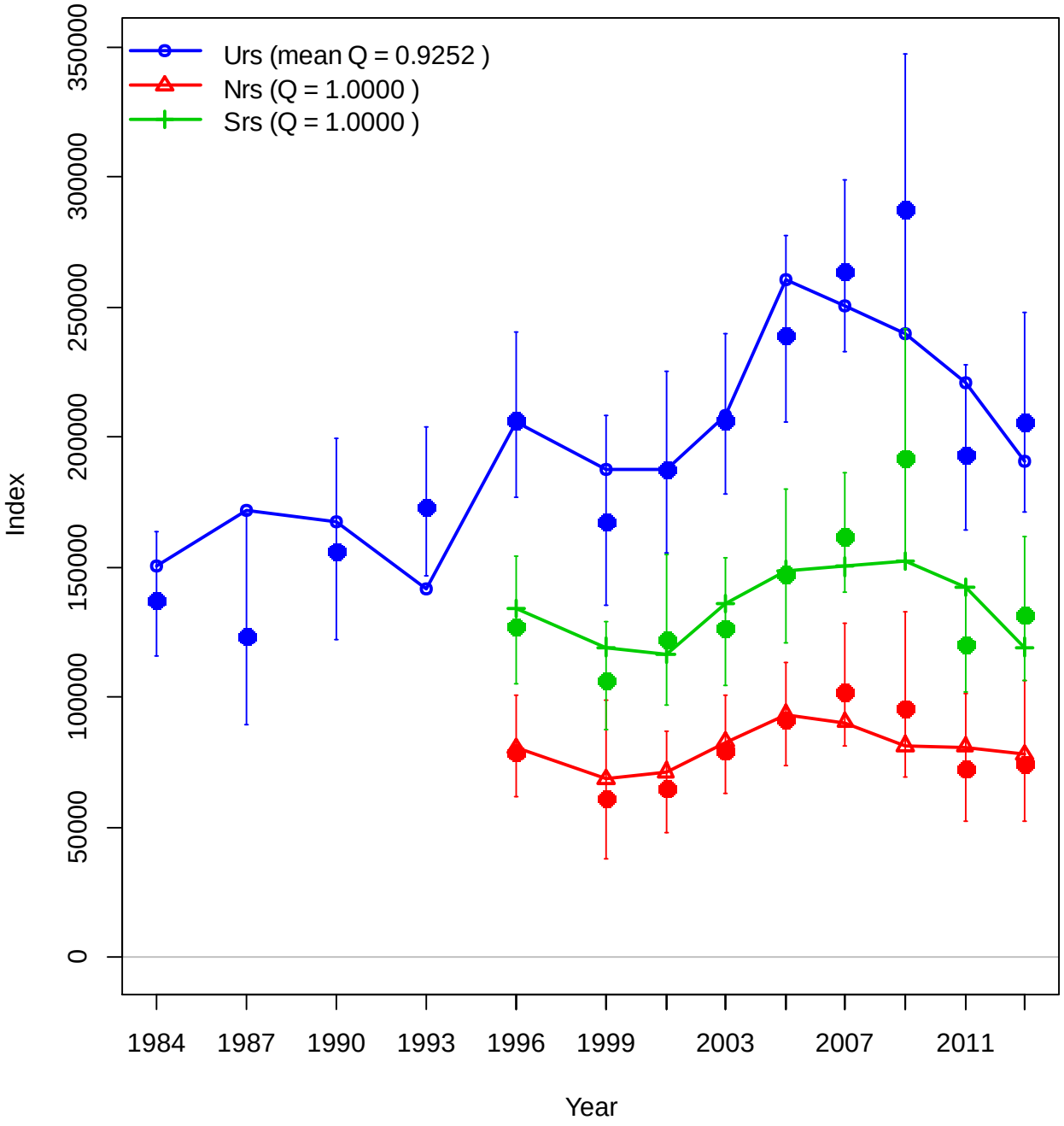

Urs (mean Q = 0.9252)
Nrs (Q = 1.0000)
Srs (Q = 1.0000)
Index
0
50000
100000
150000
200000
250000
300000
350000
1984
1987
1990
1993
1996
1999
2003
2007
2011
Year

Figure 4 – Spawning biomass for northern rock sole

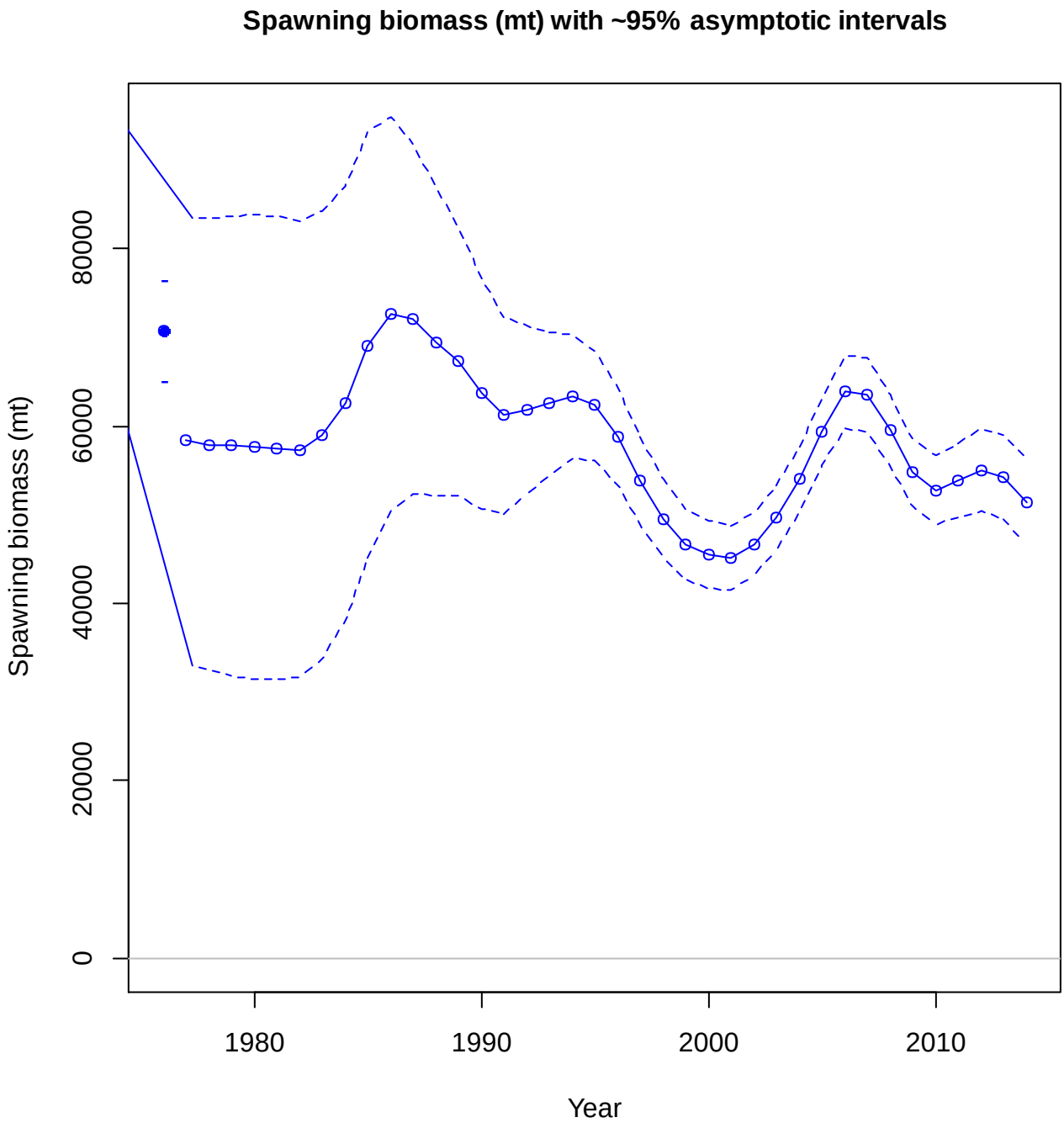


Figure 5 – Spawning biomass for southern rock sole

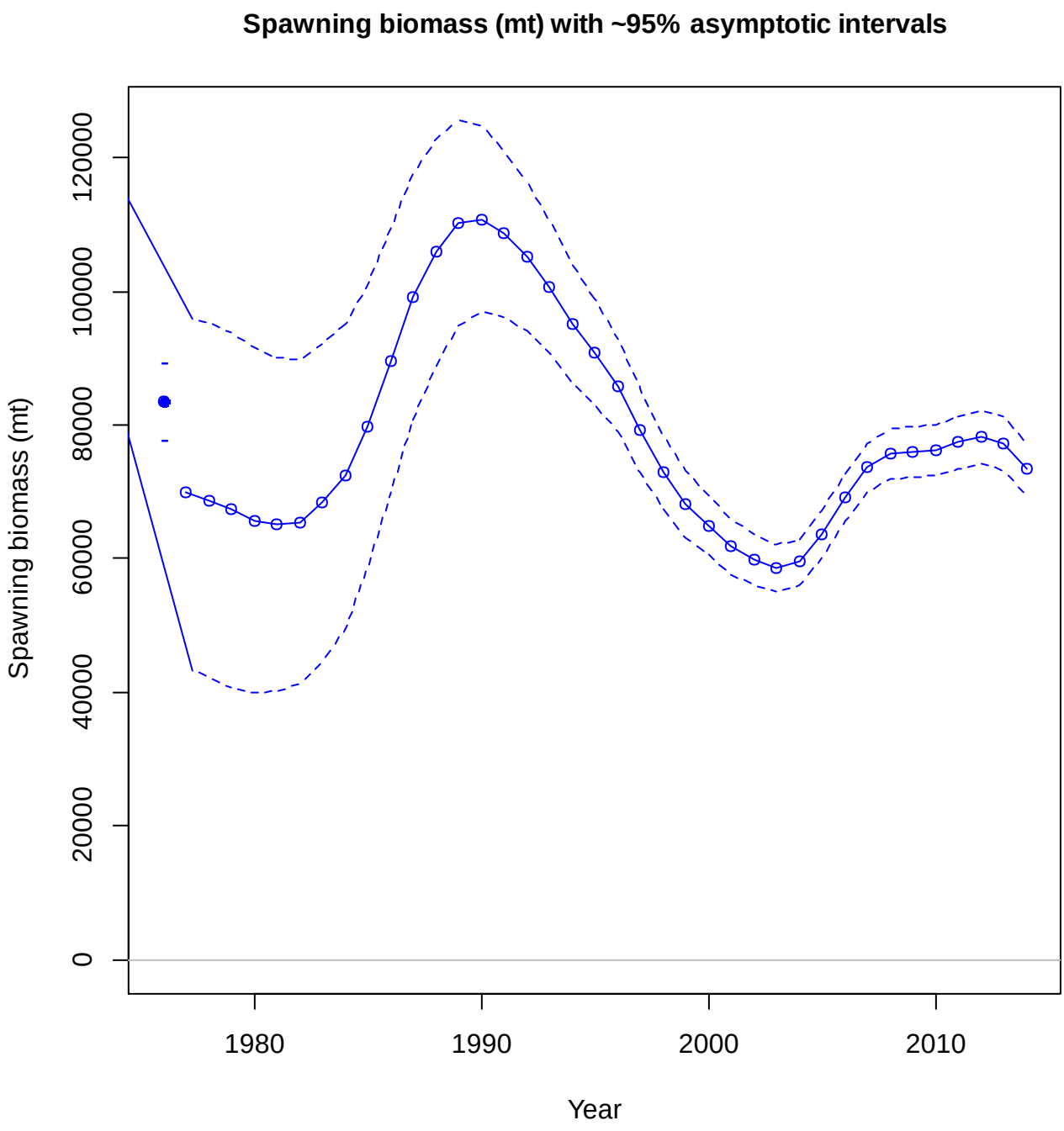


Figure 6 – Fishery length composition for northern rock sole females

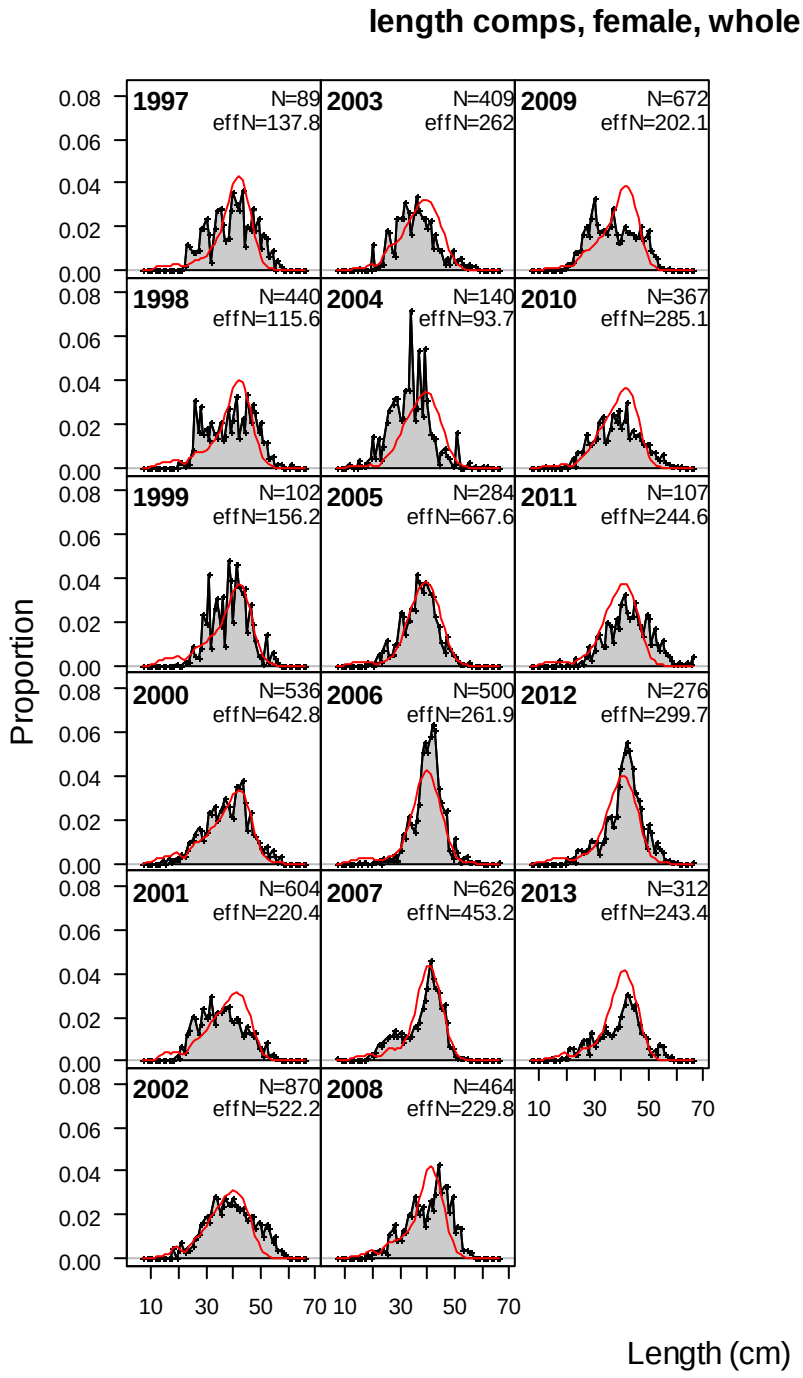


Figure 7 – Fishery length composition for northern rock sole males

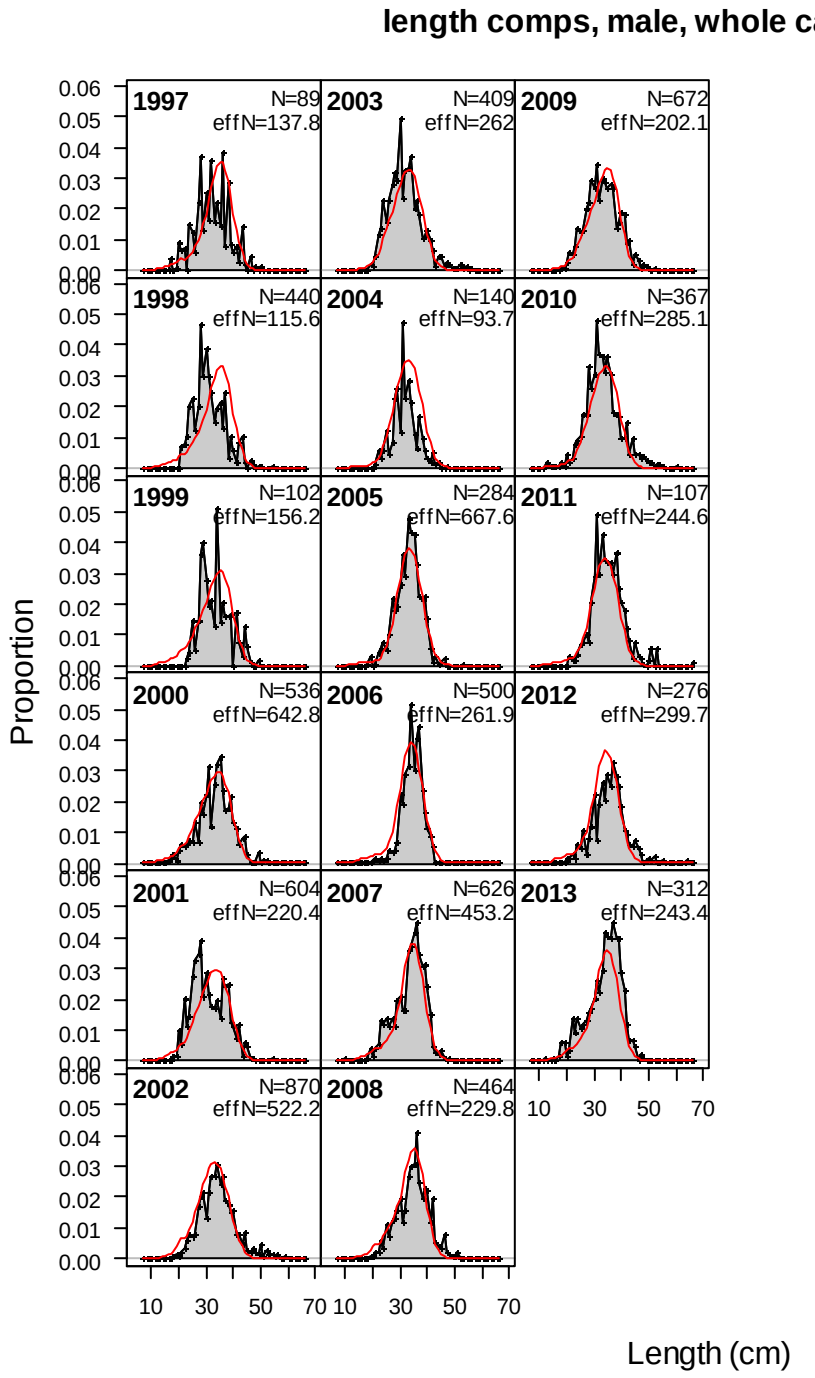


Figure 8 – Fishery length composition for southern rock sole females

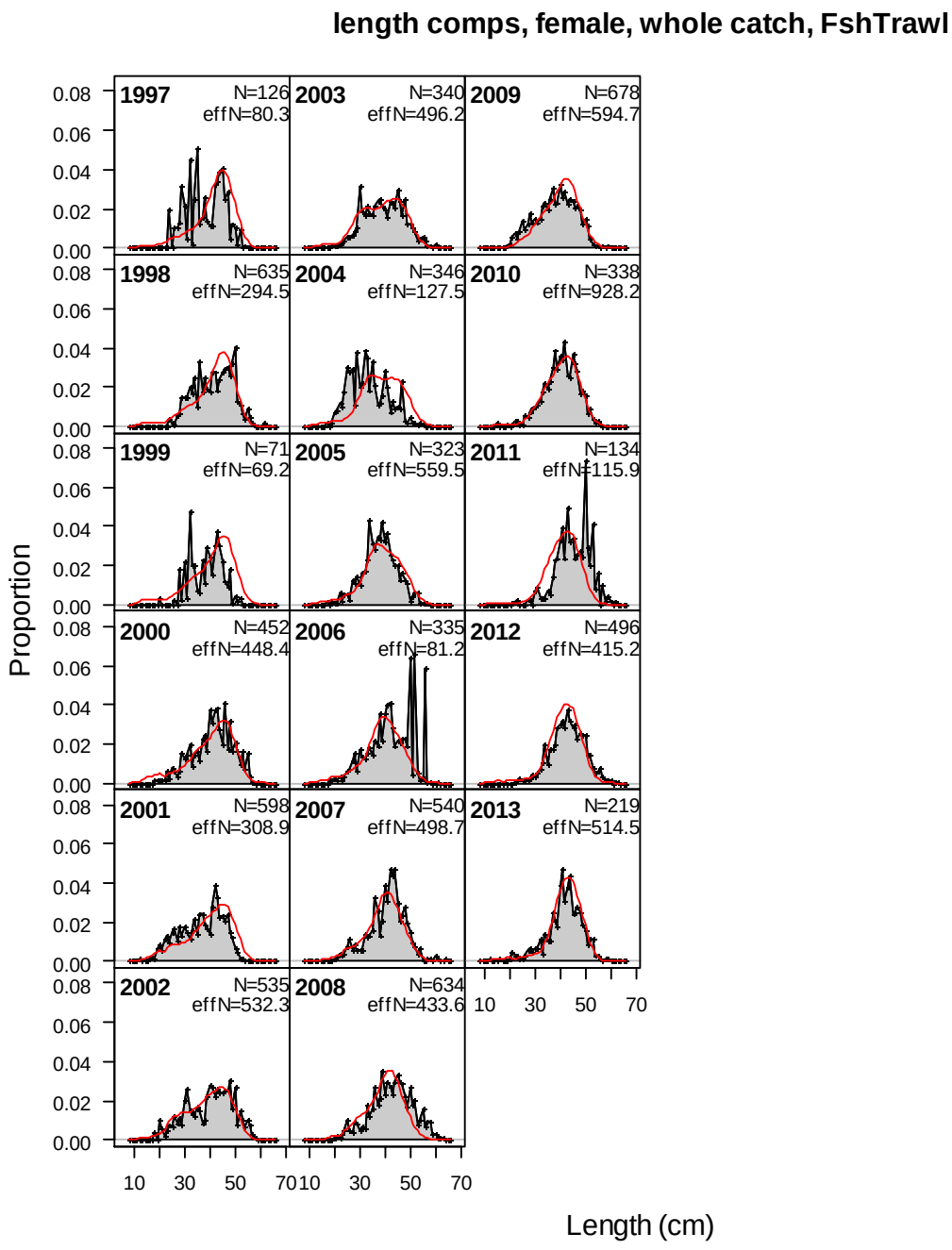


Figure 9 – Fishery length composition for southern rock sole males

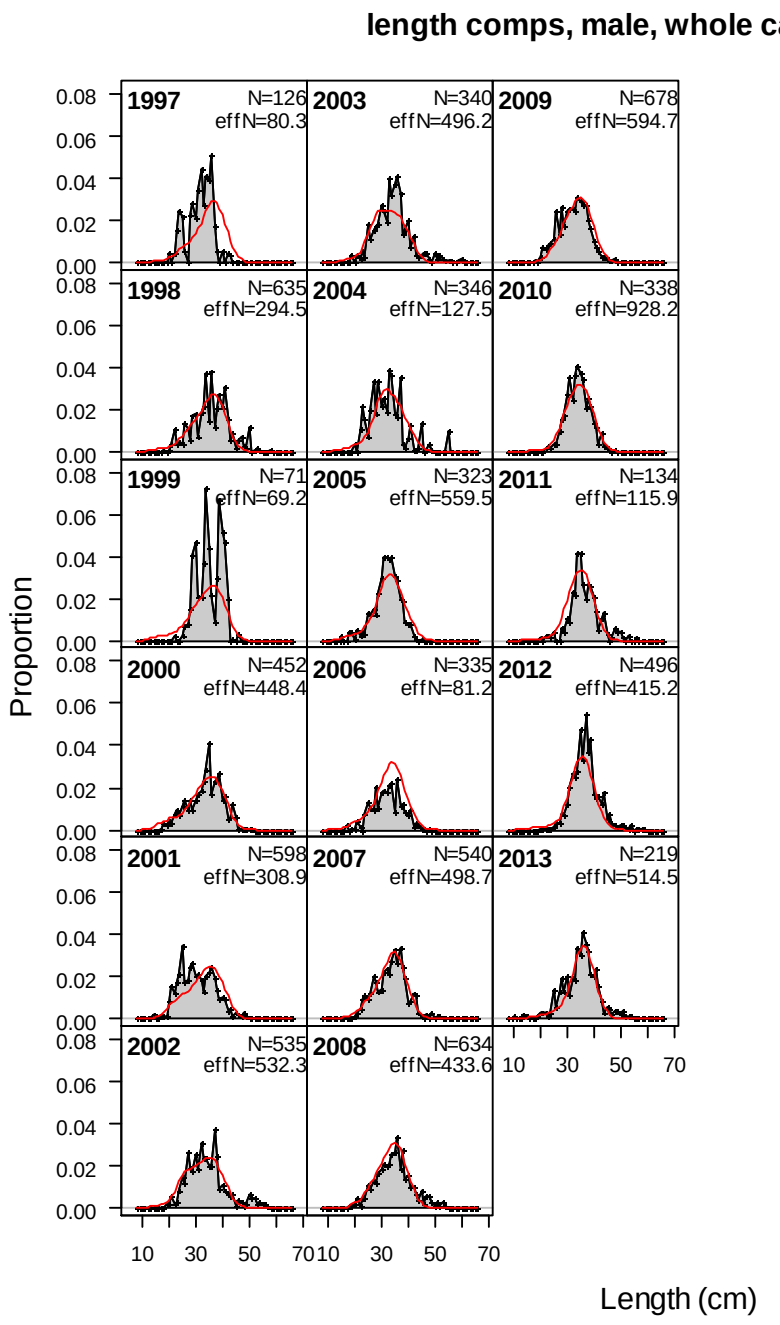
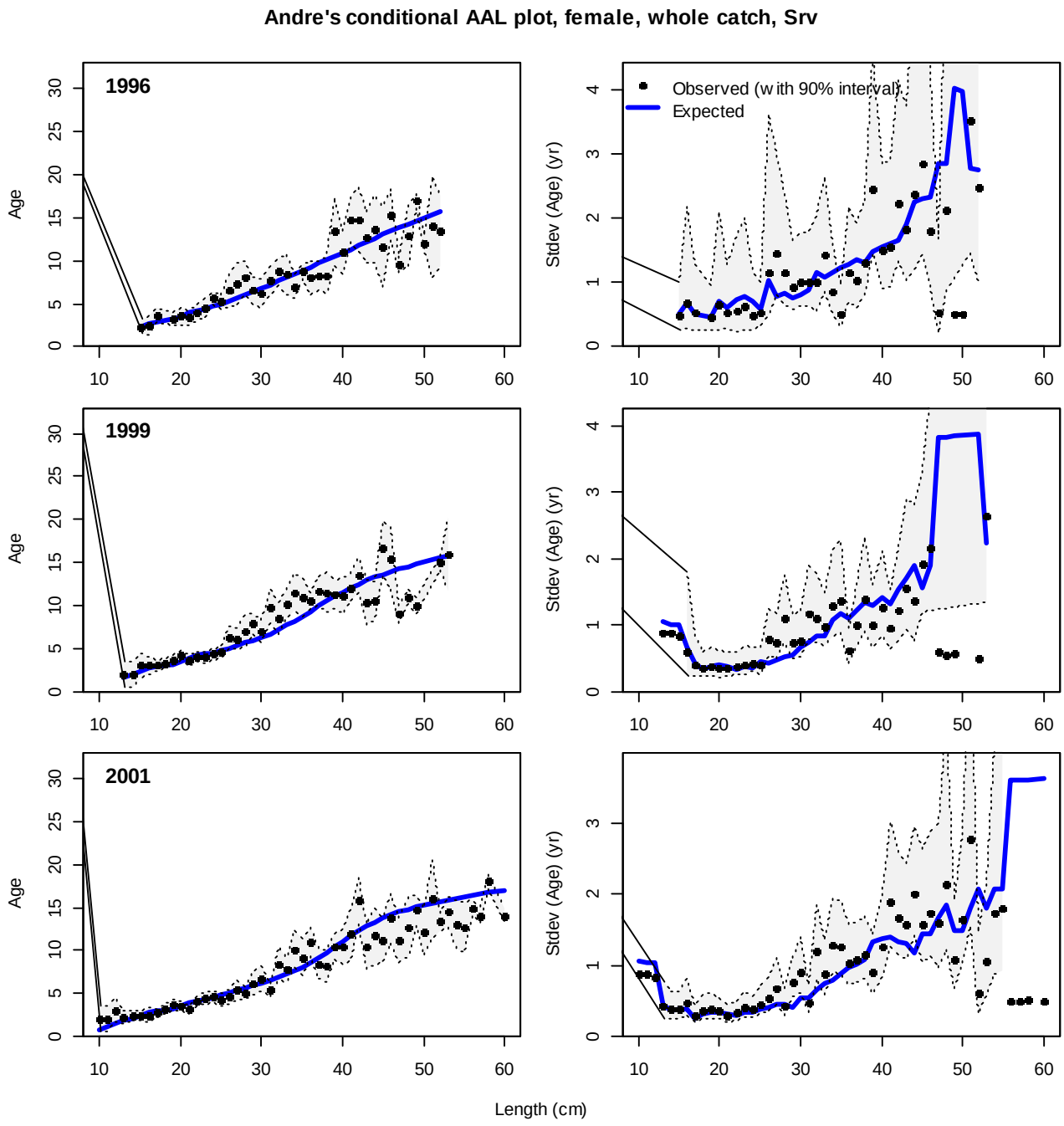
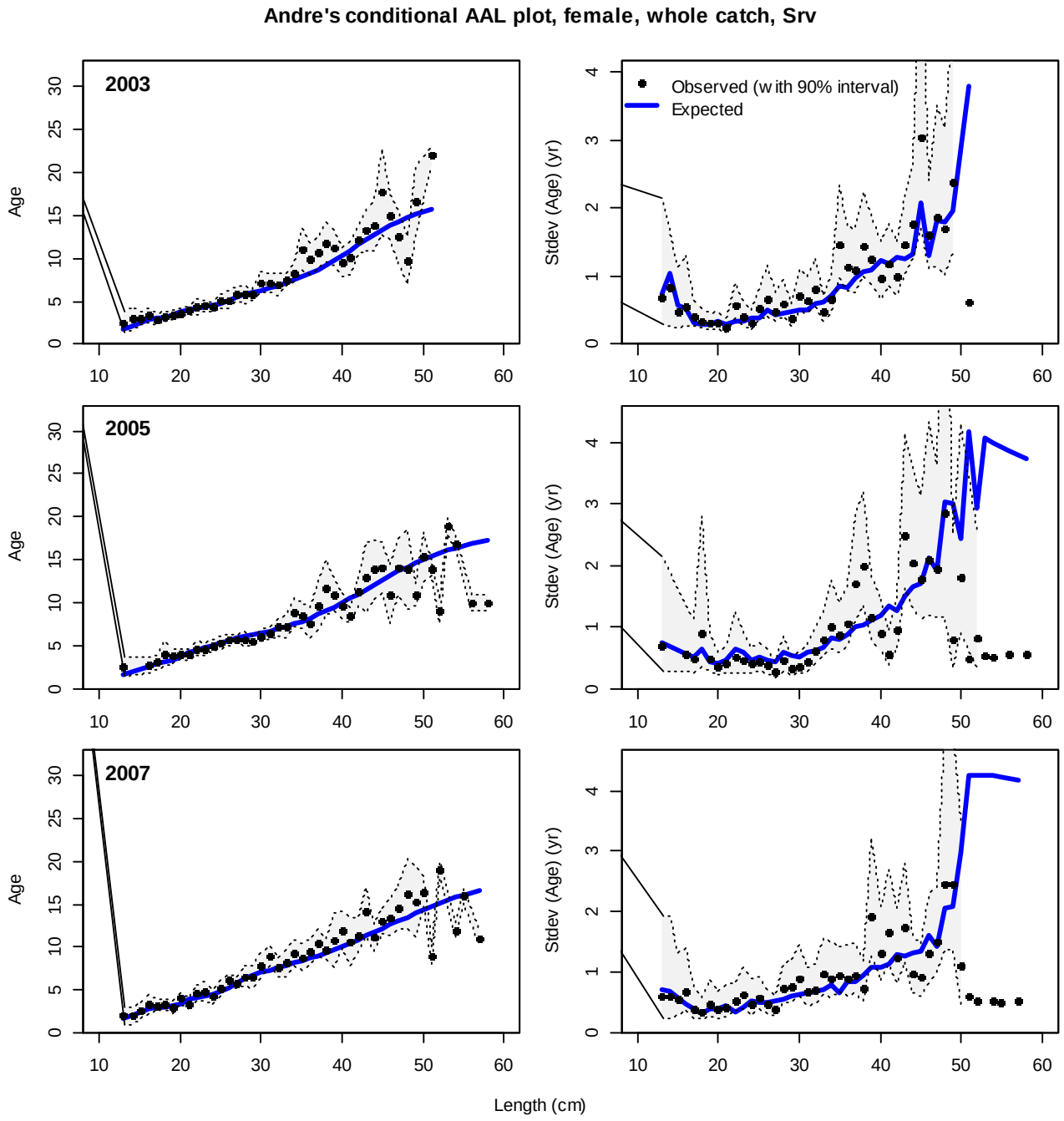


Figure 10 – Conditional survey age-at-length for northern rock sole females




Andre's conditional AAL plot, female, whole catch, Srv
2003
2005
2007
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

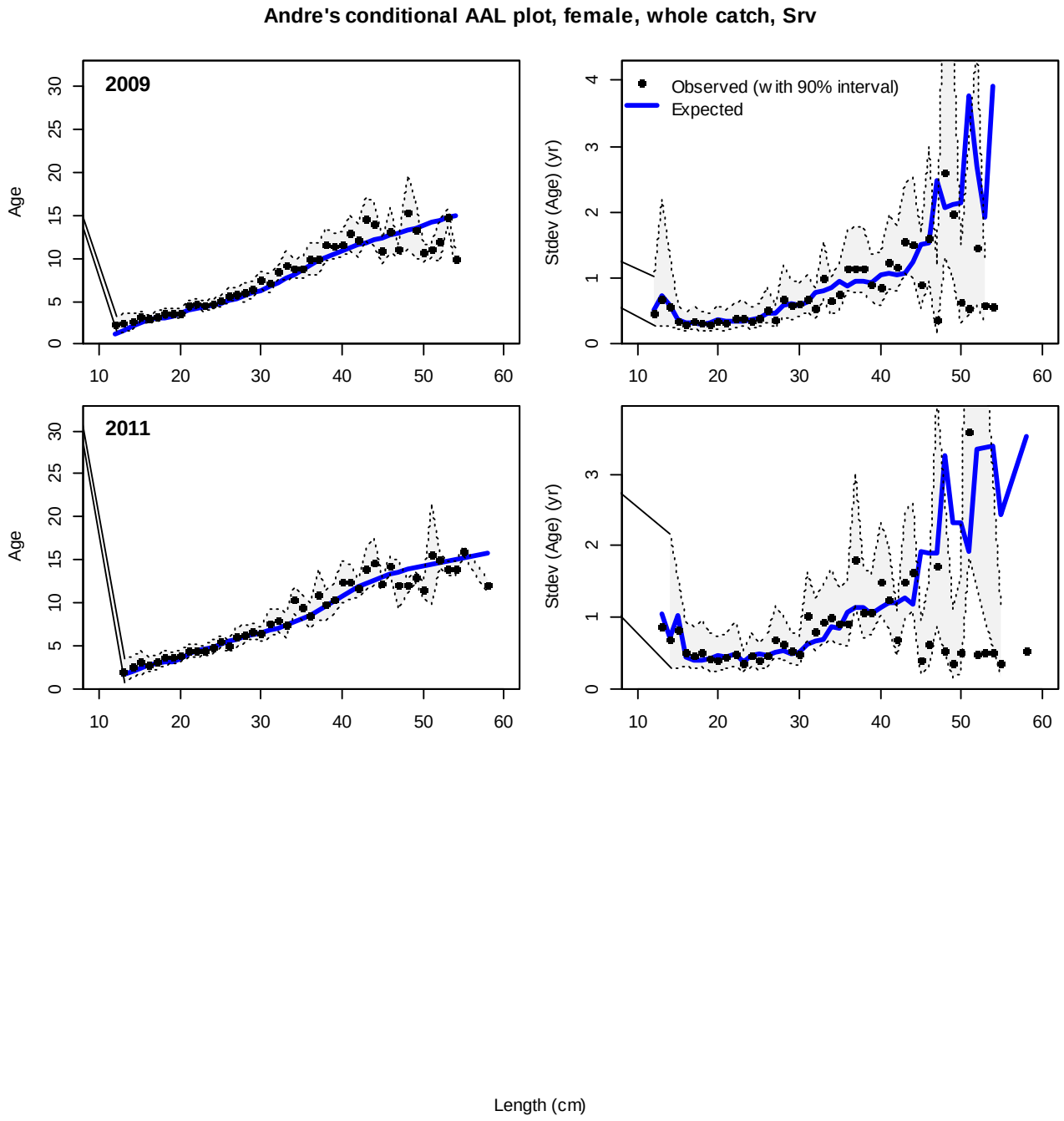
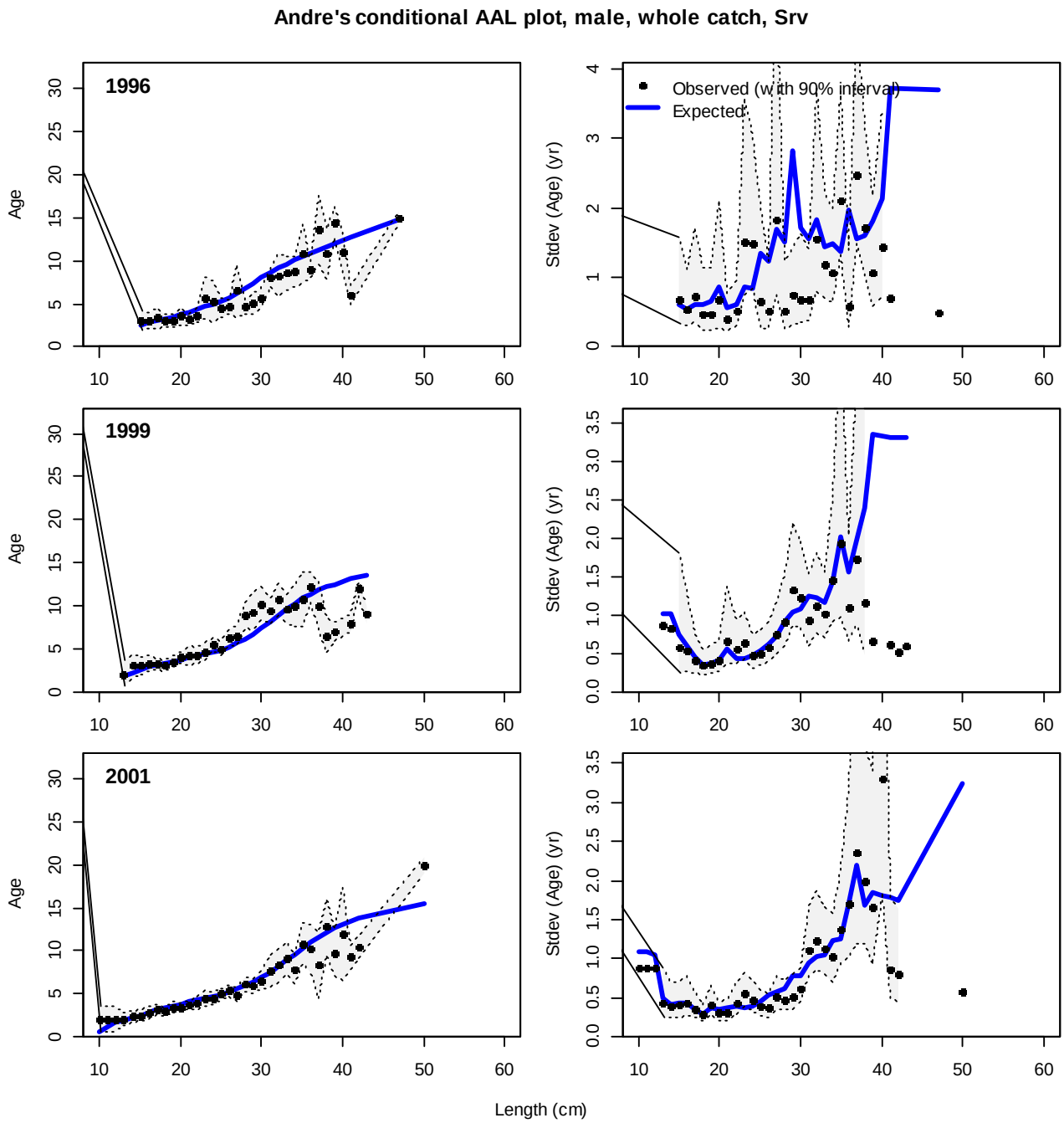
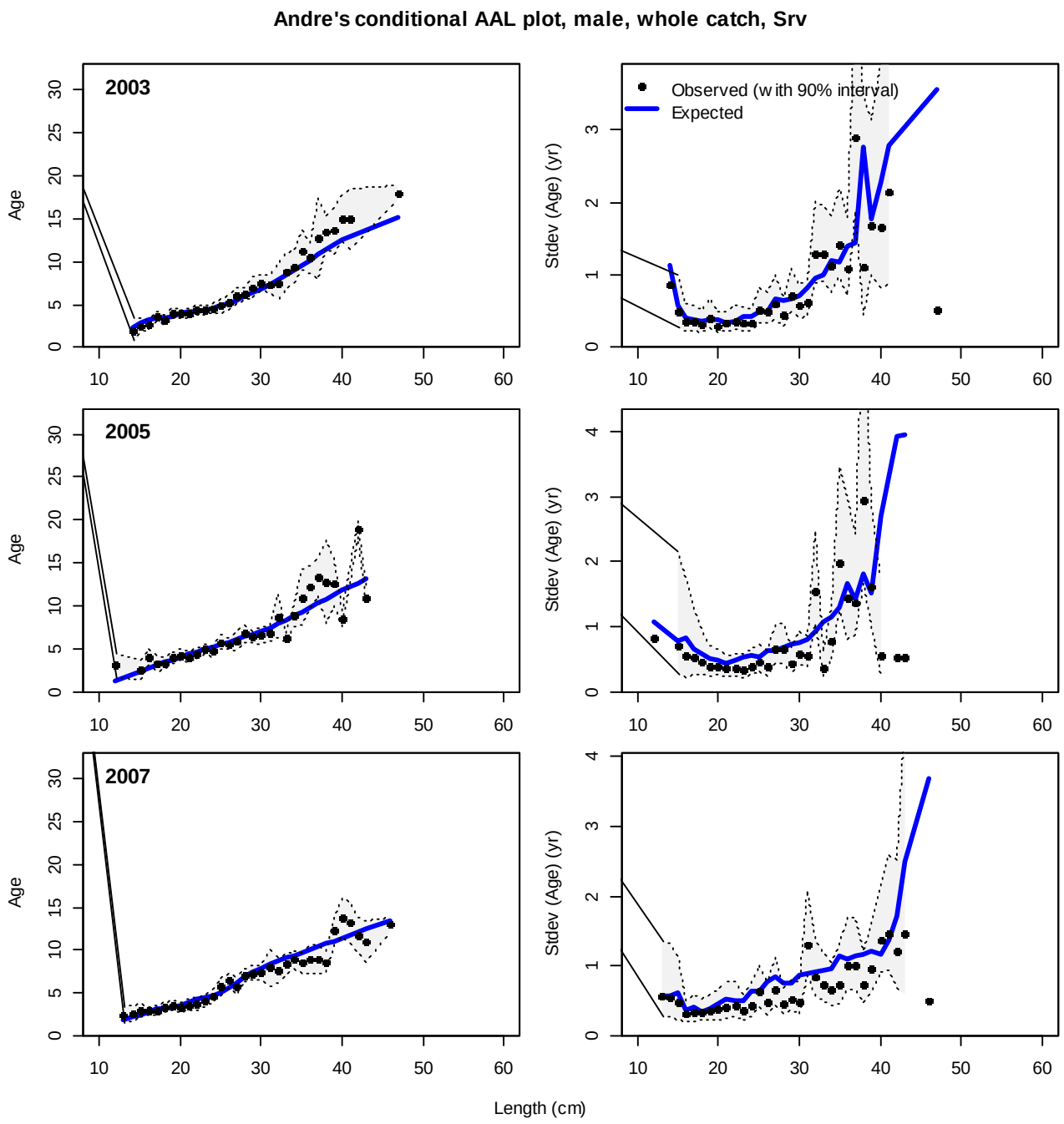

Andre's conditional AAL plot, female, whole catch, Srv
2009
2011
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

Figure 11 – Conditional survey age-at-length for northern rock sole males




Andre's conditional AAL plot, male, whole catch, Srv
2003
2005
2007
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

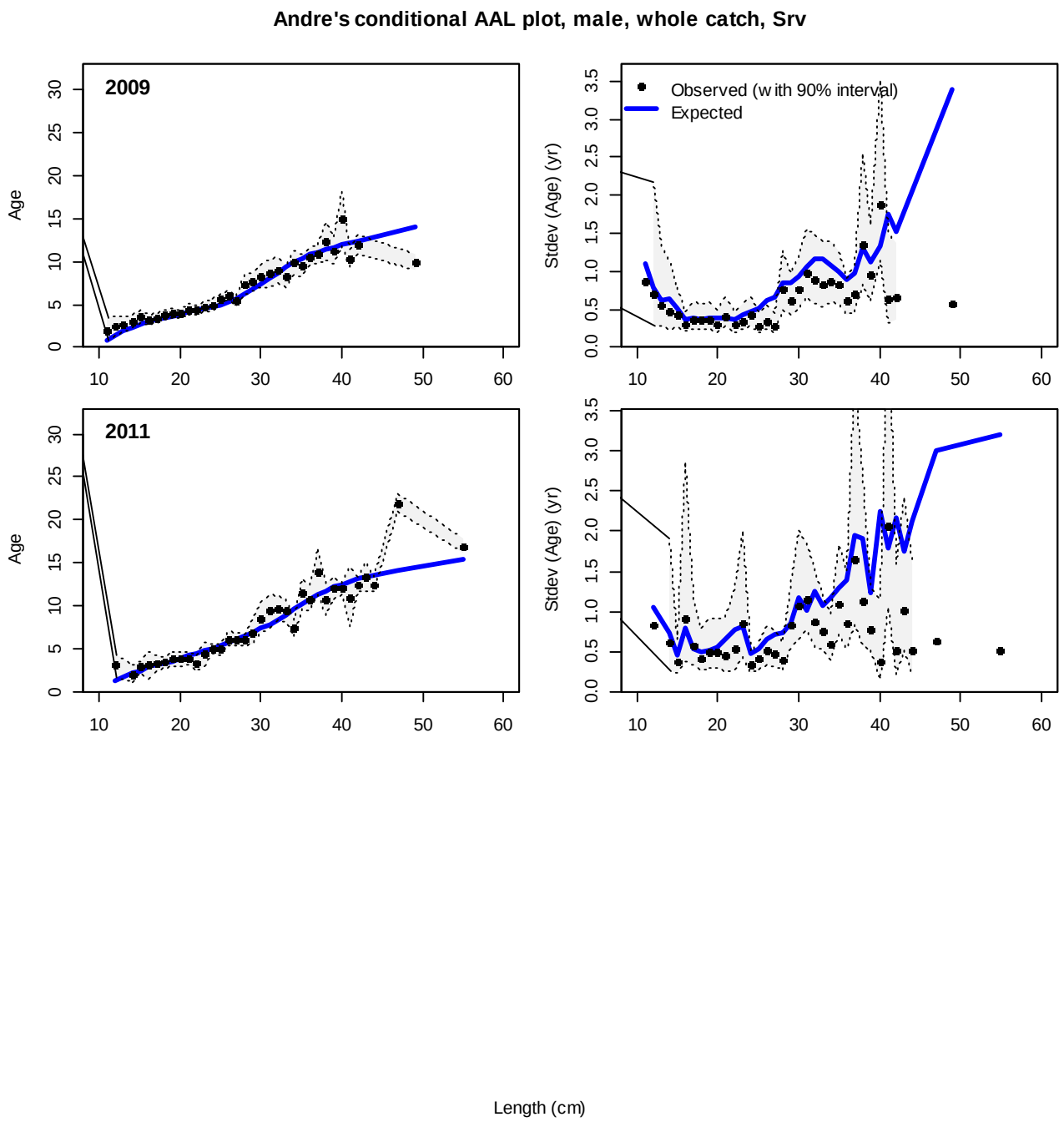
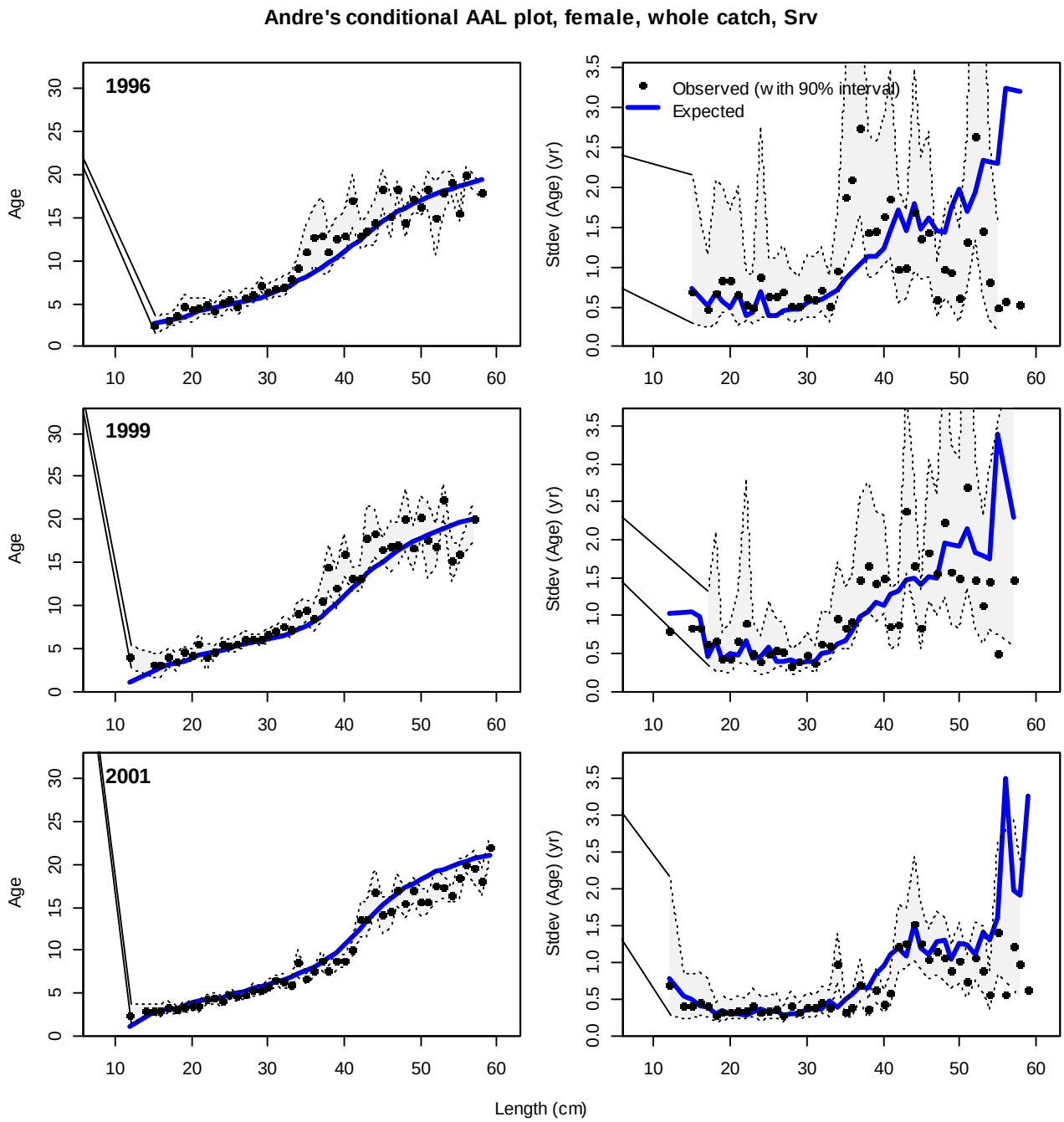
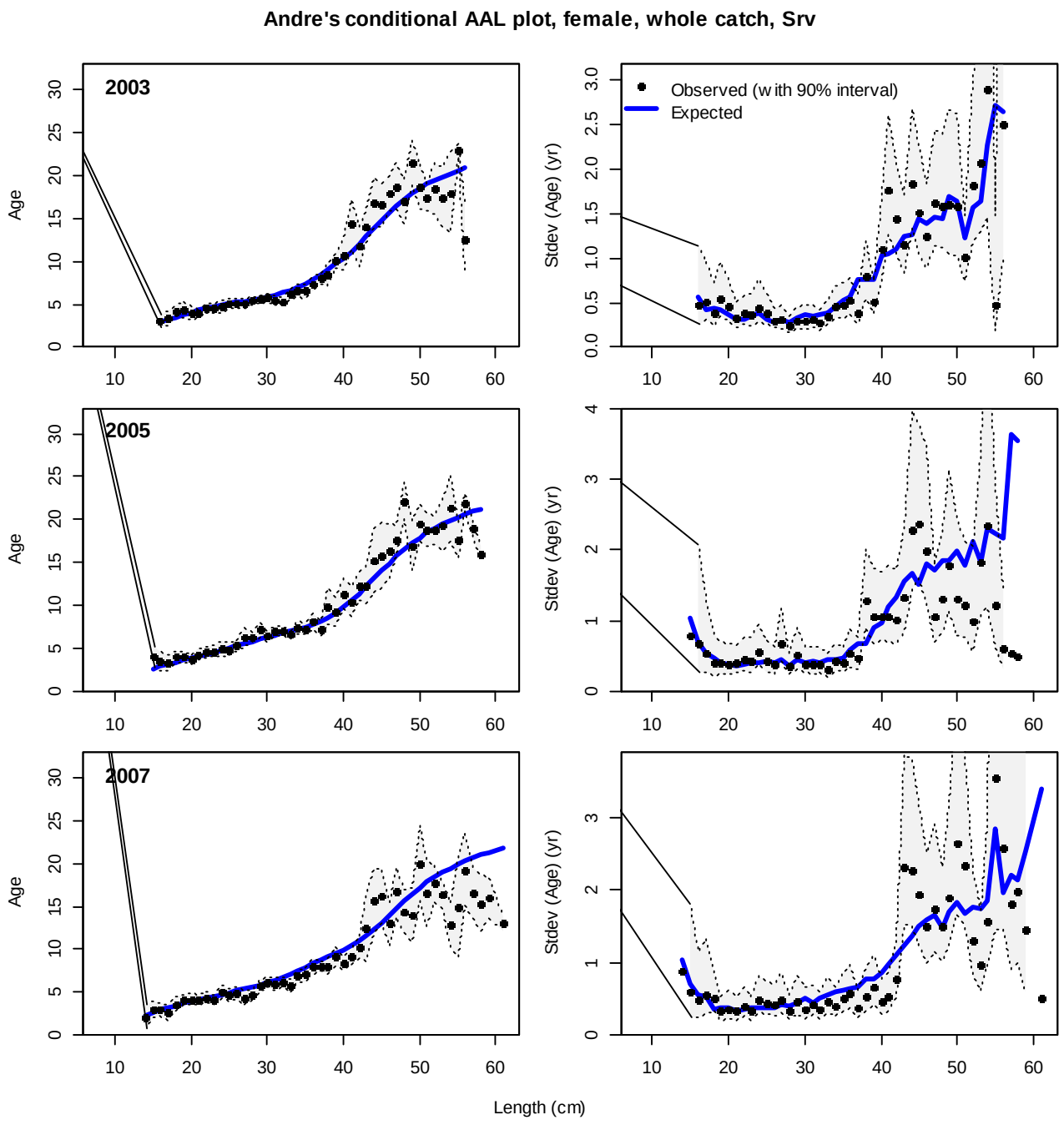

Andre's conditional AAL plot, male, whole catch, Srv
2009
2011
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

Figure 12 – Conditional survey age-at-length for southern rock sole females




Andre's conditional AAL plot, female, whole catch, Srv
2003
2005
2007
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

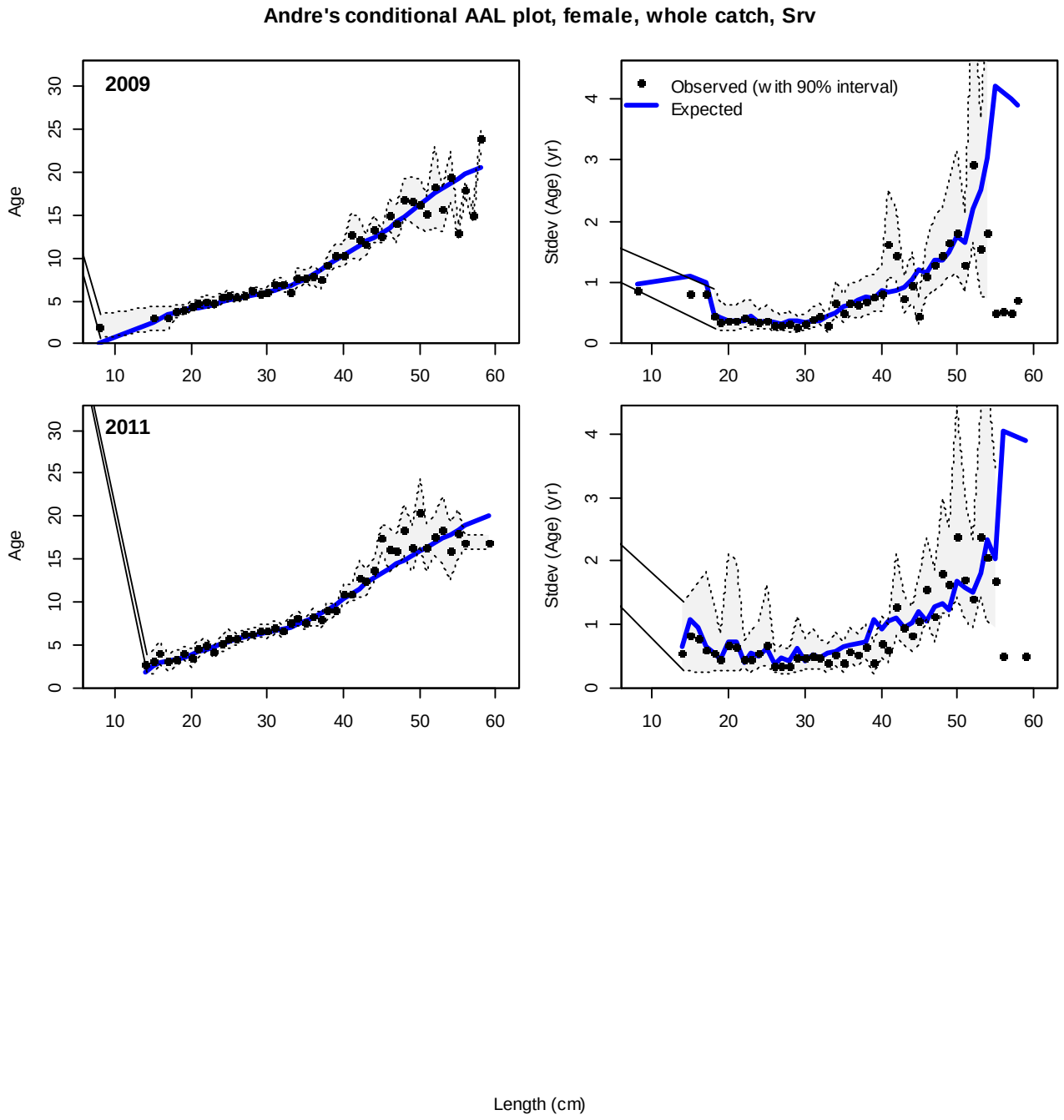
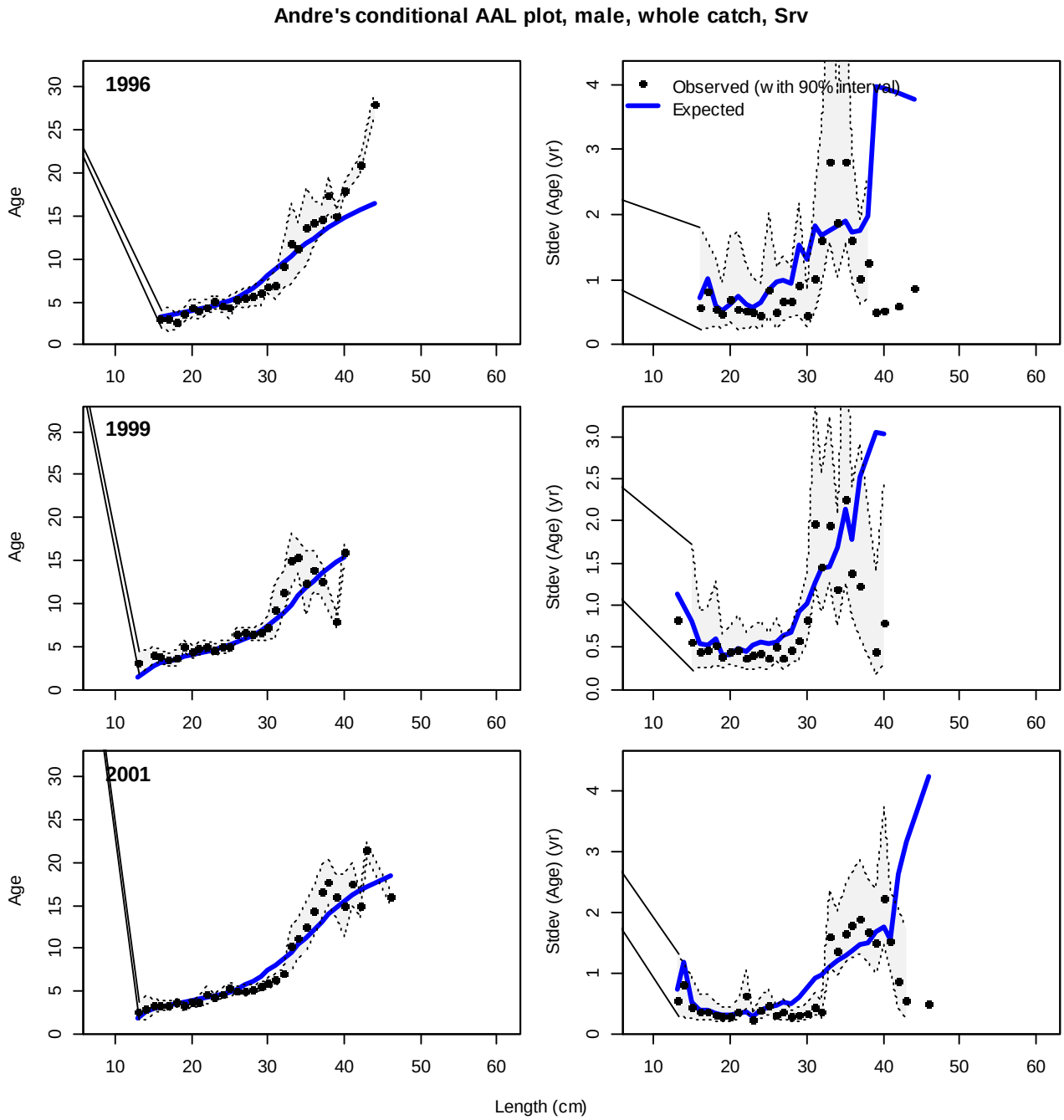
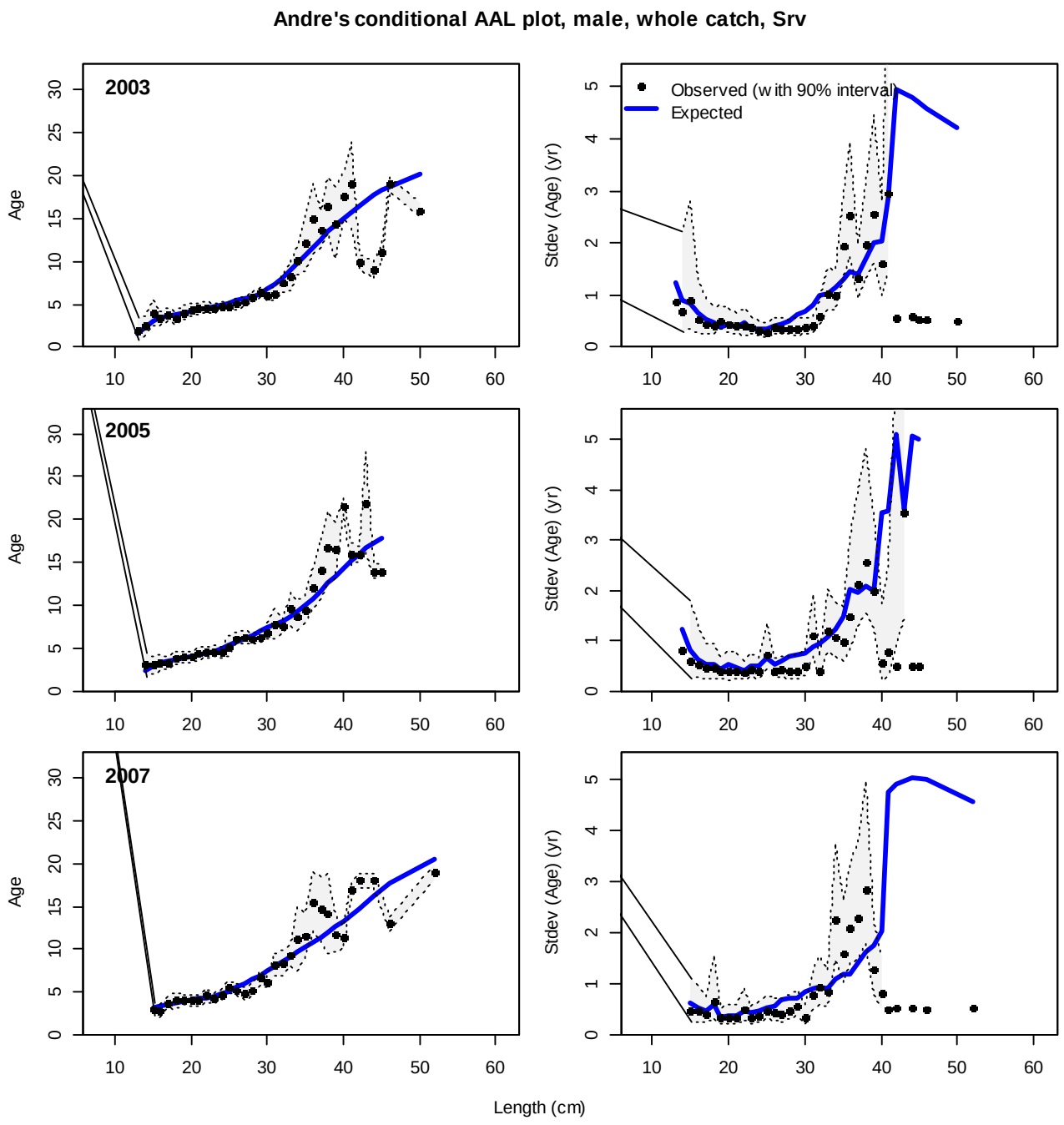
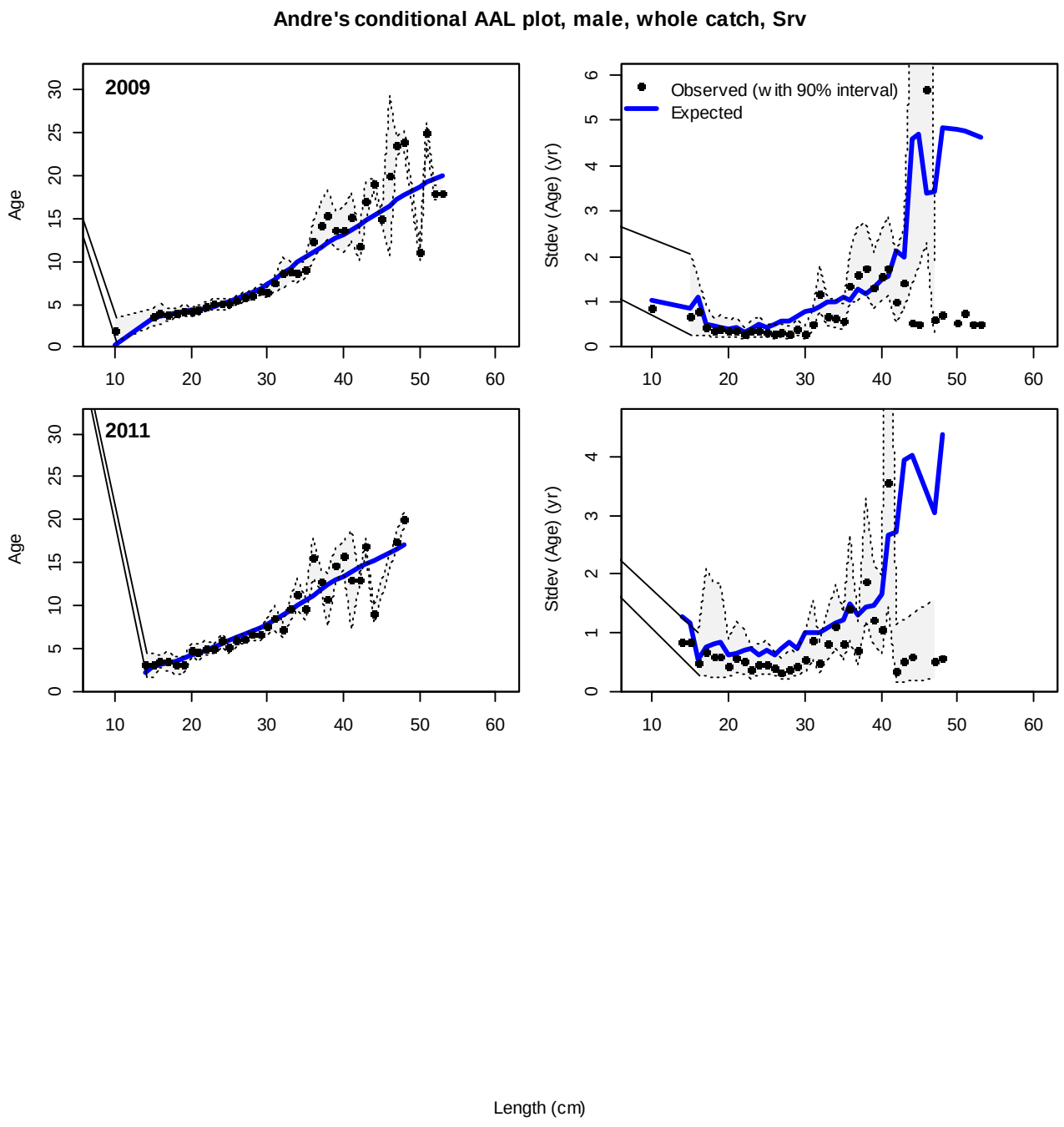

Andre's conditional AAL plot, female, whole catch, Srv
2009
2011
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

Figure 13 – Conditional survey age-at-length for southern rock sole males




Andre's conditional AAL plot, male, whole catch, Srv
2003
2005
2007
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)


Andre's conditional AAL plot, male, whole catch, Srv
2009
2011
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)